

Proceedings of

Office of Naval Research Award Number N00014-99-1-0966

IUTAM SYMPOSIUM "LAMINAR-TURBULENT TRANSITION"

1 AUGUST 1999 – 31 DECEMBER 1999

To

Office of Naval Research
Program Officer Candace Wark ONR
Code: 333
Ballston Tower One
800 North Quincy Street
Arlington, VA. 22217-5660

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June 2000

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20000615 017

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Preface

The origins of turbulent flow and the transition from laminar to turbulent flow are among the most important unsolved problems of fluid mechanics and aerodynamics. Besides being a fundamental question of fluid mechanics, there are any number of applications for information regarding transition location and the details of the subsequent turbulent flow.

The IUTAM Symposium on Laminar-Turbulent Transition, co-hosted by Arizona State University and the University of Arizona, was held in Sedona Arizona. Although four previous IUTAM Symposia bear the same appellation (Stuttgart 1979, Novosibirsk 1984, Toulouse 1989, and Sendai 1994) the topics that were emphasized were each different and reflect the evolving nature of our understanding of the transition process.

The major contributions of Stuttgart 1979 centered on nonlinear behavior and later stages of transition in two-dimensional boundary layers. Stability of closed systems was also included with Taylor vortices in different geometries. The topics of Novosibirsk 1984 shifted to resonant wave interactions and secondary instabilities in boundary layers. Pipe- and channel-flow transition were discussed as model problems for the boundary layer. Free shear layers were discussed and a heavy dose of supersonic papers appeared for the first time. The character of Toulouse 1989 was also different in that 3-D boundary layers, numerical simulations, streamwise vortices, and foundation papers on receptivity were presented. Sendai 1994 saw a number of papers on swept wings and 3-D boundary layers. Numerical simulations attacked a broader range of problems.

The Sedona 1999 meeting was almost exclusively bounded shear layers as open systems. The major impact topics were receptivity of initial disturbances, crossflow instabilities, supersonic flows, and control of transition. More papers appeared on combined numerical and experimental work. In other cases, teams from different institutes combined resources to solve complicated problems. The objectives of many of these studies were to properly define the fundamental physics of the stability and transition process. One can track certain freestream disturbances that provide the initial conditions for unstable waves in somewhat complicated geometries. As a consequence, this fundamental knowledge now enables different techniques of transition control and its subsequent decrease in drag. One expects increased emphasis on this topic. Papers on transient growth and sub-critical development of 3-D disturbances pointed to future areas of research.

Countries represented and number of participants

Australia	1	Brazil	1	Canada	2
China	2	France	7	Germany	24
Greece	1	India	2	Israel	1
Italy	1	Japan	15	Russia	11
Sweden	2	Switzerland	3	The Netherlands	1
U.K.	16	Ukraine	1	USA	42

Total participants: 132

Symposium Sponsors

International Union of Theoretical and Applied Mechanics (IUTAM)
Arizona State University
University of Arizona
ASU Unsteady Wind Tunnel
UA Computational Fluid Dynamics Laboratory
Army Research Office
Office of Naval Research
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Air Force Office of Scientific Research.

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Sunday 12 September

1800 - 2200 Reception and Registration at Poco Diablo Resort-Sedona, AZ.
(located in the Conference-Center)

Monday 13 September

0700 -0845 Registration and continental breakfast
(Registration at the Conference-Center/continental breakfast on lower patio)

0845 - 0900 **OPENING REMARKS**
KEYNOTE LECTURES
Chairman: M. Gaster

0900 - 0920 T. Tatsumi
Turbulence in the turn of the century

0920 - 1005 L. Mack
Early history of compressible linear stability theory

1005 - 1030 **BREAK**
(coffee, tea, water served in hallway)

SESSION A: RECEPTIVITY I

Chairman: V. Kozlov

1030 - 1050 P. Hammerton , E. Kerschen
Effect of leading-edge geometry and aerodynamic loading on receptivity to acoustic disturbances

1050 - 1110 L.M. Cullen , H.P. Horton
Acoustic receptivity in boundary layers with surface roughness

1110 - 1130 N. Peake , R. Lingwood
A casual stability analysis of the boundary-layer flow over a compliant wall

1130 - 1150 C. Airiau, S. Walther, A. Bottaro
Nonparallel receptivity and the adjoint PSE

1150 - 1340 **LUNCH**
(lunch served on the lower patio/Mexican Fajita Buffet)

SESSION B: RECEPTIVITY II

Chairman: V. Levchenko

1340 - 1400 Y. Kachanov
Three-dimensional receptivity of boundary layers to external perturbations

1400 - 1420 J. Wanderley , T. Corke
Boundary-layer receptivity to freestream sound on elliptic leading edges of flat plates

1420 - 1440 R. King, K. Breuer
Non-localized acoustic receptivity and subsequent disturbance growth in a Blasius boundary layer

1440 - 1500 D.G. Lasseigne, W.O. Criminale, R.D. Joslin, T.L. Jackson
Receptivity and bypass dynamics

1500 - 1520 W. Wurz, W. Herr, A. Worner, U. Rist, S. Wagner, Y. Kachanov
Study of 3-D wall roughness acoustic receptivity on an airfoil

1520 - 1540 V. Kosorygin
Experiments on receptivity, stability, and transition of 2-D laminar boundary layers with streamwise pressure gradients

1540 - 1600 E. White, W. Saric, R. Radeztsky Jr.
Leading-edge acoustic receptivity measurements using a pulsed-sound technique

1600 - 1630 **BREAK AND POSTER SESSION SET UP**
(coffee, teas, assorted soft drinks, water served in the hallway)

1630 - 1830 POSTER SESSION I (MONDAY AND TUESDAY)**1.1 S. Collis, A. Dobrinsky***Evaluation of adjoint based methods for the prediction of receptivity***1.2 Y. Su , T. Herbert***Receptivity to freestream turbulence and the effect of longitudinal vortices in boundary-layer transition***1.3 D. Nichols , P. Hammerton***Receptivity for a flat plate with a rounded leading edge***1.4 H. Grek, V. Kozlov, D. Sboev***Experiments on the receptivity of a boundary layer to a localized freestream disturbance***1.5 M. Ustinov, M. Kogan, V. Shumilkin, S. Zhigulev***Experimental study of flat-plate boundary layer receptivity to vorticity normal to leading edge***1.6 M. Katasonov , V. Kozlov***Boundary-layer longitudinal localized structures control by means of spanwise wall oscillations***1.7 C. Gmelin, U. Rist, S. Wagner***DNS of active control of disturbances in a Blasius boundary layer***1.8 M. Baumann, D. Sturzebecher, W. Nitsche***Active control of T-S instabilities on an unswept wing***1.9 A. Bakchinov, M. Katasonov, P. Alfredsson, V. Kozlov***Control of streaky structures by localized blowing and suction***1.10 D. Meyer, U. Rist, V. Borodulin, V. Gaponenko, Y. Kachanov, Q. Lian, C. Lee***Late-stage transitional boundary-layer structures. Direct numerical simulation and experiment***1.11 G. Grek, M. Katasonov, V. Kozlov, Y. Chernoray***Experimental study of a A-structure development and mechanism: Its transformation into the turbulent spot***1.12 S. Houten, J. Healey, C. Davies***Nonlinear evolution of Tollmien-Schlichting waves at finite Reynolds numbers***1.13 J. Healey***On why oblique waves in the Blasius boundary layer show stronger nonparallel effects than planar waves***1.14 R. Govindarajan, R. Narasimha***Stability of weakly nonsimilar swept-wing boundary layers***1.15 P. Taniguchi, F. Browand, R. Blackwelder***Boundary-layer transition due to the entry of a small particle***1.16 Y. Kohama, P. Alfredsson, Y. Egami, M. Kawakami***Turbulent energy production mechanism in general boundary-layer transition***1.17 S. Reddy , P. Ioannou***Energy transfer analysis of turbulent plane Couette flow***1.18 P. Hall***Nonlinear initial value problems for wave/vortex interactions in channel flows***1.19 S. Wernz , H. Fasel***Numerical investigation of resonance phenomena in wall-jet transition***1.20 S. Gaponov , B. Smorodsky***Supersonic boundary-layer receptivity to streamwise acoustic field***1.21 F. Lundell , P. Alfredsson***Feed-forward control of streak instabilities in plane Poiseuille flow by localized suction***1.22 R. Messing, M. Kloker***Effect of suction through arrays of holes on a 3-D boundary layer investigated by spatial direct numerical simulation***Tuesday 14 September****0700 - 0820 Registration and continental breakfast**

(Registration at the Conference-Center/continental breakfast on lower patio)

SESSION C: ATTACHMENT LINE AND GENERAL TOPICS

Chairman: R. Kobayashi

0820 - 0840	R. Mukund, P. Viswanath, J. Crouch <i>Relaminarization and retransition of accelerated turbulent boundary layers on a convex surface</i>
0840 - 0900	A. Dietz, C. Coleman, J. Laub, D. Poll <i>Effect of wall temperature on roughness induced attachment-line transition</i>
0900 - 0920	S. Seddougui, B. Orme <i>Nonlinear Instability of Hypersonic Flow over a cone</i>
0920 - 0940	M. Gaster <i>On the growth of waves in boundary layers</i>
0940 - 1020	BREAK (coffee, tea, water served in hallway)

SESSION D: 3-D TRANSITION IN 2-D FLOWS

Chairman: D. Arnal

1020 - 1040	S. Bake, H. Fernholz <i>The formation of secondary structures and random perturbations in the development of periodic Lambda structures in a laminar boundary layer</i>
1040 - 1100	M. Asai, M. Minagawa, M. Nishioka <i>Instability and breakdown of the three-dimensional high-shear layer associated with a near-wall low-speed streak</i>
1100 - 1120	R. Bowles <i>On vortex interaction in the later stages of boundary-layer transition</i>
1120 - 1140	E. Malkiel, V. Levinski, M. Rosenfeld, J. Cohen <i>The evolution of hairpin vortices in shear flows</i>
1140 - 1200	M. Medeiros , M. Mendonca <i>Nonlinear three-dimensional wavetrains of small amplitude in boundary layers: experiments, theory and computations</i>
1200 - 1220	V. Kozlov, G. Grek <i>Stationary and nonstationary streaky structures and secondary instability of boundary layers</i>
1220 - 1340	LUNCH (lunch served on lower patio/Hot Dog, Burger Buffet)

SESSION E: CONTROL

Chairman: R. Narasimha

1340 - 1400	Y. Fukunishi, I. Ebina, R. Kobayashi <i>Generation of oblique waves in a Blasius boundary layer by thin Piezo-film actuators attached to the wall surface</i>
1400 - 1420	P. Cathalifaud , P. Luchini <i>Optimal control by blowing and suction at the wall of algebraically growing boundary-layer disturbances</i>
1420 - 1440	C. Davies, P. Carpenter, D. Lockerby <i>A novel velocity-vorticity method for simulating boundary-layer disturbance evolution and control</i>
1440 - 1500	P. Andersson, M. Berggren, D. Henningson <i>Optimal three-dimensional perturbations in the Blasius boundary layer</i>
1500 - 1520	N. Yurchenko , J. Delfs <i>Optimal control of boundary layers under body forces</i>

1520 - 1720 BREAK AND POSTER SESSION SET UP

(coffee, teas, assorted soft drinks, water served in the hallway)

1720 - 1750 Poster session break down**1900 - 2130 BANQUET**

(located in the conference center building)

Wednesday 15 September

0630 - 0730	continental breakfast served on lower patio
0715-0730	board buses for Grand Canyon-main entrance

0715 - 1730 GRAND CANYON TOUR

Thursday 16 September

0700 - 0800 **Registration and continental breakfast**
 (Registration at the Conference-Center/continental breakfast on lower patio)

SESSION F: GENERAL TOPICS

Chairman: H. Zhou

0820 - 0840 **S. Becker, K. Condie, C. Stoots, D. McEligot**
Reynolds-stress development in the viscous layer of a transitional boundary layer

0840 - 0900 **J. Watmuff**
Distortion of Tollmien-Schlichting waves by leading-edge vortices

0900 - 0920 **P. Moresco , J. Healey**
Convective and absolute instability in the mixed convection boundary layer over a vertical flat plate

0920 - 0940 **A. Cabal, J. Szumbarski, J. Floryan,**
Stability of Poiseuille flow in a corrugated channel

0940 - 1000 **R. Govindarajan , R. Narasimha**
The transition zone on a heated axisymmetric body

1000 - 1030 **BREAK**
 (coffee, tea, water served in hallway)

SESSION F: GENERAL TOPICS CONTINUED

Chairman: J. van Ingen

1030 - 1050 **G. Walker , J. Hughes**
The occurrence of natural transition phenomena in periodic transition on axial compressor blades

1050 - 1110 **J.P. Gostelow, H.P. Hodson, G.J. Walker**
Comparisons between triggered turbulent spots and unsteady transition phenomena on compressor and turbine blading

1110 - 1130 **M. Matsubara, A. Bachinov, J. Fransson, P. Alfredsson**
Growth and breakdown of streaky structures in boundary layer transition induced by freestream turbulence

1130 - 1150 **A. Tumin**
Onset of turbulence in circular pipe flows

1150 - 1210 **J. Reuter , D. Rempfer**
A hybrid spectral/finite-difference scheme for the simulation of pipe-flow transition

1210 - 1320 **LUNCH**
 (lunch served on lower patio /Chef's Deli Buffet)

SESSION G: SUPERSONIC

Chairman: H. Fasel

1320 - 1340 **S. Gaponov**
Transition of supersonic boundary layers (experiment and theory review)

1340 - 1400 **C. Mielke, L. Kleiser**
Investigation of transition to turbulence in a 3-D supersonic boundary layer

1400 - 1420 **E. Reshotko , A. Tumin**
The blunt body paradox: A case for transient growth

1420 - 1440 **M. Malik**

- Hypersonic boundary-layer receptivity and stability
1440 - 1500 A. Fezer , M. Kloker
Spatial direct numerical simulation of transition phenomena in supersonic flat-plate boundary layers
- 1500 - 1530 BREAK**
(coffee, teas, assorted soft drinks, water served in the hallway)
- 1530 - 1550 A. Maslov, S. Mironov**
Experimental investigations of the hypersonic boundary-layer stability
- 1550 - 1610 S. Schneider**
Development of a Mach-6 quiet-flow Ludwieg tube for transition research
- 1610 - 1630 X. Yuan, H. Zhou**
A numerical study for a small amplitude T-S wave in a supersonic boundary layer
- 1650 - 1710 BREAK AND POSTER SESSION SET UP**
(coffee, teas, assorted soft drinks, water served in the hallway)
- 1710 - 1910 POSTER SESSION II (THURSDAY AND FRIDAY)**
- 2.1 X. Zhong**
DNS of boundary-layer receptivity to freestream sound for hypersonic flows over blunt elliptical cones
- 2.2 N. Semionov , A. Kosinov**
Experimental study of supersonic boundary-layer receptivity in controlled conditions
- 2.3 V. Lysenko, A. Kosinov, Y. Yermolaev**
Development of artificial disturbances in the boundary layer on a plate and in the wake behind it at supersonic free-flow speed
- 2.4 A. Kosinov, Y. Yermolaev, N. Semionov**
On anomalous wave processes in supersonic boundary layer
- 2.5 A. Karabis, S. Shaw, V. Theofilis**
On the inviscid spatial instability of supersonic boundary-layer flow along bodies of revolution
- 2.6 D. Bountin, A. Shiplyuk, A. Sidorenko**
Experimental investigations of disturbance development in the hypersonic boundary layer on a conical model
- 2.7 S. Sakaue, M. Asai, M. Nishioka**
On the receptivity process of supersonic laminar boundary layer
- 2.8 D. Mitra, R. Seshadri, K. Rao, R. Govindarajan**
Low-order stability theory for non-parallel compressible boundary layer flow
- 2.9 A. Kosinov, Y. Yermolaev, N. Semionov**
On correspondence of laminar-turbulent transition processes at natural and controlled supersonic experiments on flat plate
- 2.10 C. Stemmer, M. Kloker**
Later stages of transition of an airfoil boundary layer flow excited by a harmonic point source
- 2.11 L. Schouveiler, P. LeGal, M.P. Chauve**
Experiments on the transition to turbulence of the flow between a stationary and a rotating disk
- 2.12 M. Höglberg , D. Henningson**
Secondary instability of crossflow vortices in Falkner-Skan-Cooke boundary layers
- 2.13 C. Cossu, J. Chomaz, M. Costa**
Maximum growth of Görtler vortices
- 2.14 P. Ardoneau, D. Aymer de la Chevalerie**
Non-normality of the Görtler operator and spatial amplification
- 2.15 I. Gergis , J. Liu**
Linear stability of the supersonic turbulent boundary layer to Görtler vortices on a concave wall
- 2.16 C. Whang , X. Zhong**
Direct numerical simulation of Görtler instability in hypersonic boundary layers
- 2.17 F. Bahri, Y. Kohama, J. Iino and Aota**
Effect of the pressure gradients on the secondary instability of Görtler flow
- 2.18 H. Stuer, A. Gyr, W. Kinzelbach**

Laminar-turbulent transition of a separation flow on a forward facing step

2.19 A. Dovgal

Flow instability in laminar separation bubbles

2.20 R. Lingwood , P. Alfredsson

Experimental study of the stability of the Bödewadt layer

2.21 G. Han, A. Tumin, I. Wygnanski

Late stage of transition in a circular pipe flow

2.22 P. Wassermann , M. Kloker

DNS investigations of the development and control of crossflow vortices in a 3-D boundary layer flow

2.23 Y. Kachanov, D. Koptsev, B. Smorodskiy

3-D stability and receptivity of 2-D self-similar boundary layer with adverse pressure gradient

2.24 E. Reshotko, M. Vargas, H. Reed

Relation of glaze ice formations on swept wings to crossflow instability

2.25 T. Wintergerste , L. Kleiser

Secondary stability analysis of nonlinear crossflow vortices

Friday 17 September

0700 - 0800 Registration and continental breakfast

(Registration at the Conference-Center/continental breakfast on lower patio)

SESSION H: CROSSFLOW

Chairman: E. Kerschen

0800 - 0820 D. Arnal , A. Seraudie, J. Archambaud

Influence of surface roughness and suction on the receptivity of a swept wing boundary layer

0820 - 0840 T. Herbert

Stability and transition in 3-D boundary layers

0840 - 0900 W. Koch

Absolute/convective instability analysis of secondary crossflow vortices in a 3-D boundary layer

0900 - 0920 C. Abegg, H. Bippes, E. Janke

Stabilization of boundary-layer flows subject to crossflow instability with the aid of suction

0920 - 0940 Y. Yokokawa, Y. Fukunishi, N. Itoh

Numerical study of excitation of two different instabilities in e-D boundary layer on a yawed cylinder

0940 - 1000 G. Bonfigli , M. Kloker

Three-dimensional boundary-layer transition phenomena investigated by spatial direct numerical simulation

1000 - 1030 BREAK

(coffee, tea, water served in hallway)

1030 - 1050 F. Bertolotti

On the connection between crossflow vortices and attachment-line instabilities

1050 - 1110 J.S. Luo , H. Zhou

A theoretical investigation of the development of the stationary crossflow vortices in the boundary layer on a swept wing

1110 - 1130 V. Levchenko , V. Scherbakov

Experimental study of traveling waves in 3-D boundary layer on a swept wing

1130 - 1150 S. Takagi, N. Itoh, N. Tokugawa

Characteristic features of traveling disturbances originating from a point source on a rotating-disk

1150 - 1210 N. Itoh

Multimode instability of the 3-D boundary layer along an infinite attachment line

1210 - 1340 LUNCH

(lunch served on lower patio/East meets West Buffet)

SESSION I: WALL JETS AND SEPARATION

Chairman: E. Reshotko

- 1340 - 1400 **J. Seidel , H. Fasel**
Numerical investigation of the heat transfer mechanisms in wall-jet transition
- 1400 - 1420 **U. Maucher, U. Rist, S. Wagner**
Secondary disturbance amplification and transition in laminar separation bubbles
- 1420 - 1440 **V. Theofanis**
Global linear instabilities in laminar separated boundary layer flow
- 1440 - 1500 **B. Wang, D. Boducki, L. Redekopp,**
Transition in separated flows via global instability
- 1500 - 1520 **A. Dovgal , A. Boiko**
Effect of harmonic excitation on instability of laminar separation bubble on an airfoil
- 1520 - 1540 **S. Hein**
Linear and nonlinear nonlocal instability analyses for two-dimensional laminar separation bubbles
- 1540 - 1550 **Closing Remarks**
- 1550 - 1620 **BREAK AND POSTER SESSION SET UP**
(coffee, teas, assorted soft drinks, water served in the hallway)
- 1620 - 1840 **POSTER SESSION II CONTINUED**
- 1840 - 1910 **Poster session breakdown**

REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 06/07/2000	3. REPORT TYPE AND DATES COVERED Proceedings 8/1/99 – 12/31/99	
4. TITLE AND SUBTITLE IUTAM Symposium "Laminar-Turbulent Transition"		5. FUNDING NUMBERS N00014-99-1-0966	
6. AUTHORS William S. Saric			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Arizona Board of Regents for Arizona State University Office of Research and Creative Activities P.O. Box 871603 Tempe, AZ. 85287-1603		8. PERFORMING ORGANIZATION REPORT NUMBER 99PR07687-00	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research Program Officer Candace Wark ONR Code 333 Ballston Tower One 800 North Quincy St. Arlington, VA. 22217-5660		10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION / AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The IUTAM Symposium on Laminar-Turbulent Transition, co-hosted by Arizona State University and the University of Arizona, was held in Sedona Arizona. Although four previous IUTAM Symposia bear the same appellation (Stuttgart 1979, Novosibirsk 1984, Toulouse 1989, and Sendai 1994) the topics that were emphasized were each different and reflect the evolving nature of our understanding of the transition process. The Sedona 1999 meeting was almost exclusively bounded shear layers as open systems. The major impact topics were receptivity of initial disturbances, crossflow instabilities, supersonic flows, and control of transition. More papers appeared on combined numerical and experimental work. In other cases, teams from different institutes combined resources to solve complicated problems. The objectives of many of these studies were to properly define the fundamental physics of the stability and transition process. One can track certain freestream disturbances that provide the initial conditions for unstable waves in somewhat complicated geometries. As a consequence, this fundamental knowledge now enables different techniques of transition control and its subsequent decrease in drag. One expects increased emphasis on this topic. Papers on transient growth and sub-critical development of 3-D disturbances pointed to future areas of research.			
14. SUBJECT TERMS Laminar-Turbulent Transition; receptivity; initial disturbances, crossflow instabilities; supersonic flows		15. NUMBER OF PAGES 11	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UU	18. SECURITY CLASSIFICATION OF THIS PAGE UU	19. SECURITY CLASSIFICATION OF ABSTRACT UU	20. LIMITATION OF ABSTRACT UU